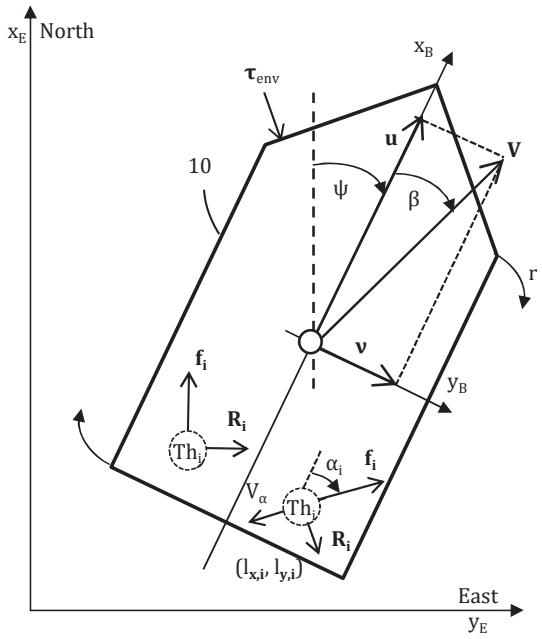

North
East
$x_E$
$y_E$
$x_B$
$y_B$
$\tau_{env}$
u
v
r
ψ
β
ν
10
$f_i$
$R_i$
$Th_i$
$\alpha_i$
$V_\alpha$
$(l_{x,i}, l_{y,i})$

Fig. 1

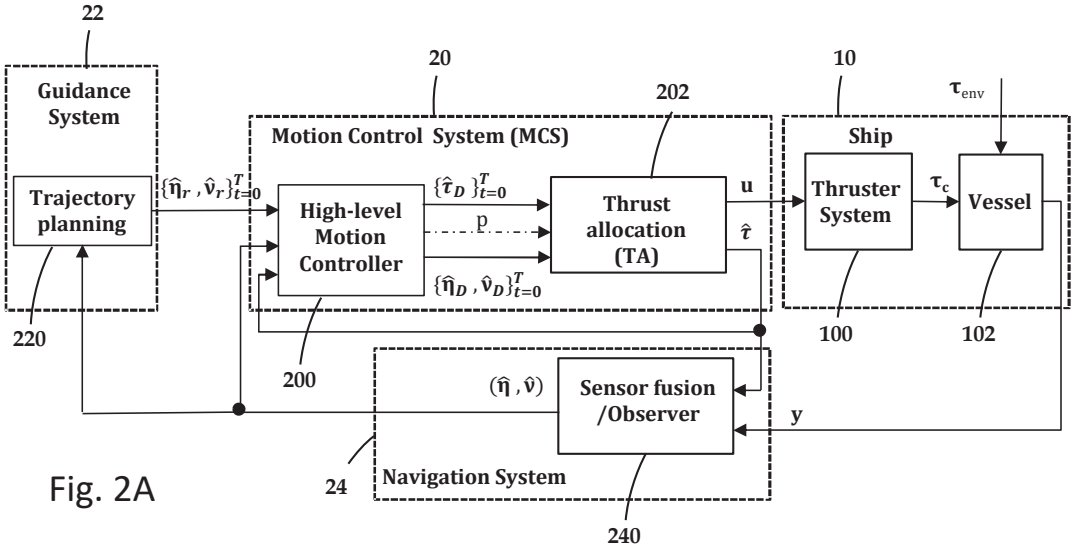

22
Guidance System
Trajectory planning
220
$\{\hat{\eta}_r, \hat{\nu}_r\}_{t=0}^T$
20
Motion Control System (MCS)
High-level Motion Controller
200
$\{\hat{\tau}_D\}_{t=0}^T$
p
$\{\hat{\eta}_D, \hat{\nu}_D\}_{t=0}^T$
202
Thrust allocation (TA)
u
$\hat{\tau}$
10
Ship
Thruster System
100
$\tau_c$
Vessel
102
$\tau_{env}$
$(\hat{\eta}, \hat{\nu})$
Sensor fusion /Observer
y
24
Navigation System
240

Fig. 2A

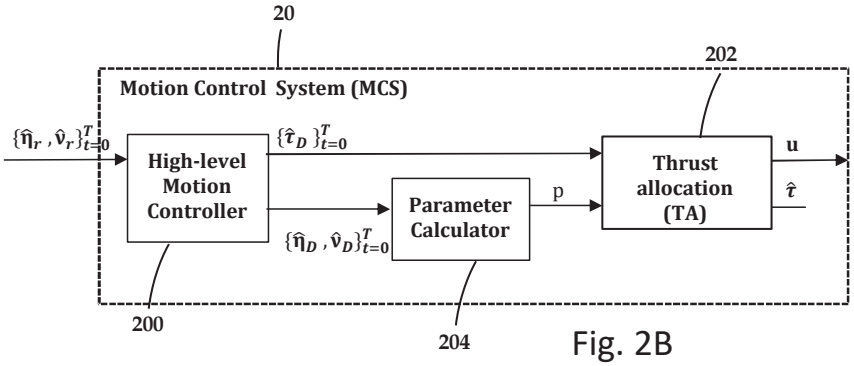

20
202
Motion Control System (MCS)
$\{\hat{\eta}_r, \hat{v}_r\}_{t=0}^{T}$
High-level Motion Controller
$\{\hat{\tau}_D\}_{t=0}^{T}$
Thrust allocation (TA)
u
$\hat{\tau}$
Parameter Calculator
p
$\{\hat{\eta}_D, \hat{v}_D\}_{t=0}^{T}$
200
204

Fig. 2B

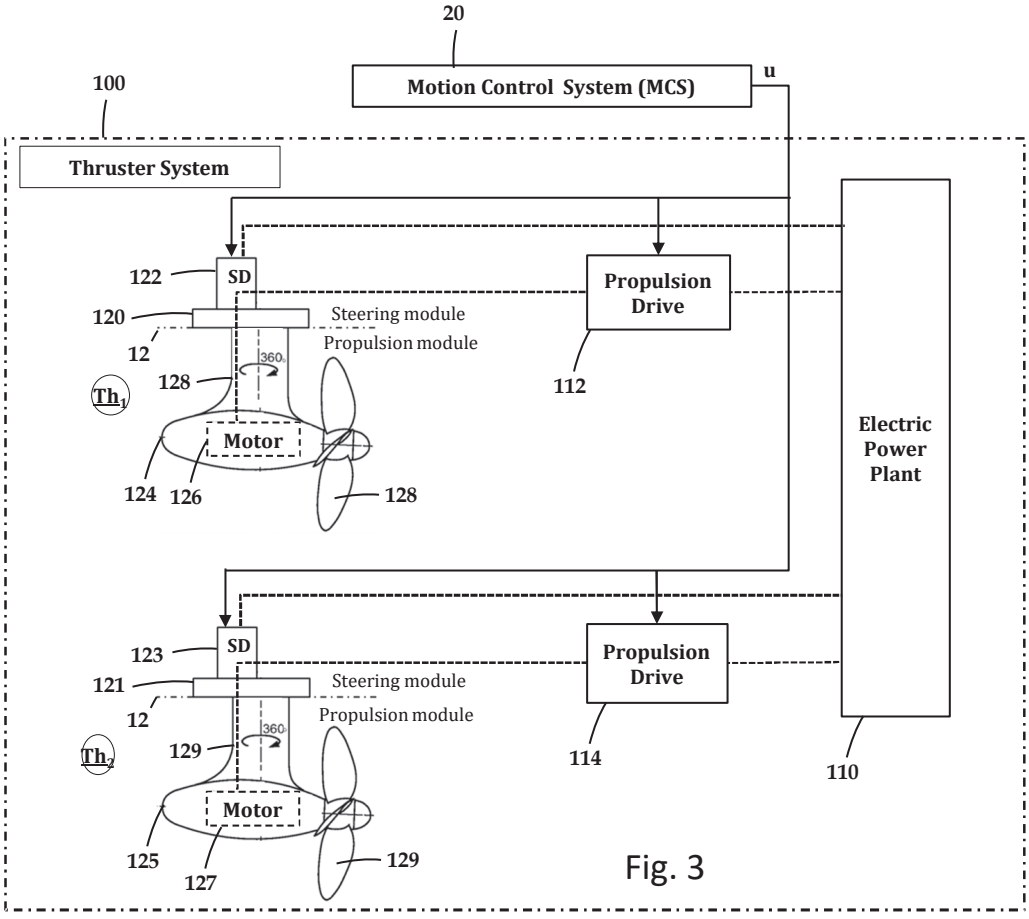

20
Motion Control System (MCS)
u
100
Thruster System
122
SD
120
Steering module
Propulsion module
12
360
128
$Th_1$
Motor
124
126
128
Propulsion Drive
112
Electric Power Plant
123
SD
121
Steering module
Propulsion module
12
360
129
$Th_2$
Motor
125
127
129
Propulsion Drive
114
110

Fig. 3

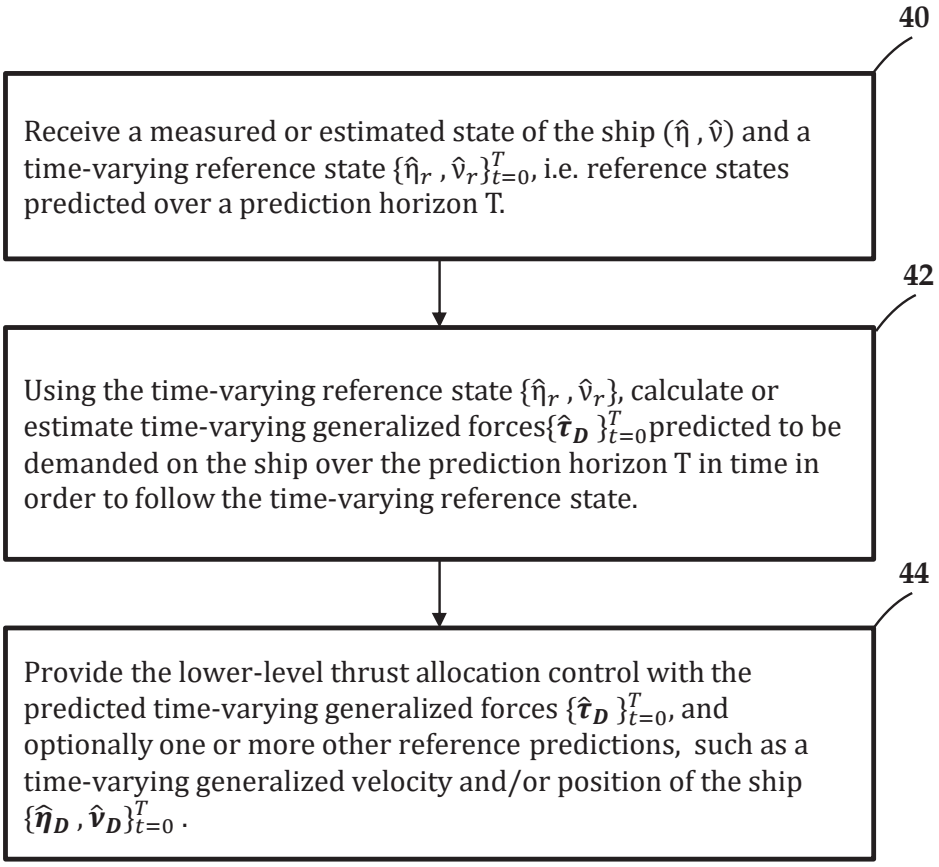

40
Receive a measured or estimated state of the ship ($\hat{\eta}$ , $\hat{\nu}$) and a time-varying reference state $\{\hat{\eta}_r , \hat{\nu}_r\}_{t=0}^{T}$, i.e. reference states predicted over a prediction horizon T.
42
Using the time-varying reference state $\{\hat{\eta}_r , \hat{\nu}_r\}$, calculate or estimate time-varying generalized forces$\{\hat{\boldsymbol{\tau}}_{\boldsymbol{D}}\}_{t=0}^{T}$predicted to be demanded on the ship over the prediction horizon T in time in order to follow the time-varying reference state.
44
Provide the lower-level thrust allocation control with the predicted time-varying generalized forces $\{\hat{\boldsymbol{\tau}}_{\boldsymbol{D}}\}_{t=0}^{T}$, and optionally one or more other reference predictions, such as a time-varying generalized velocity and/or position of the ship $\{\hat{\boldsymbol{\eta}}_{\boldsymbol{D}} , \hat{\boldsymbol{\nu}}_{\boldsymbol{D}}\}_{t=0}^{T}$ .

Fig. 4

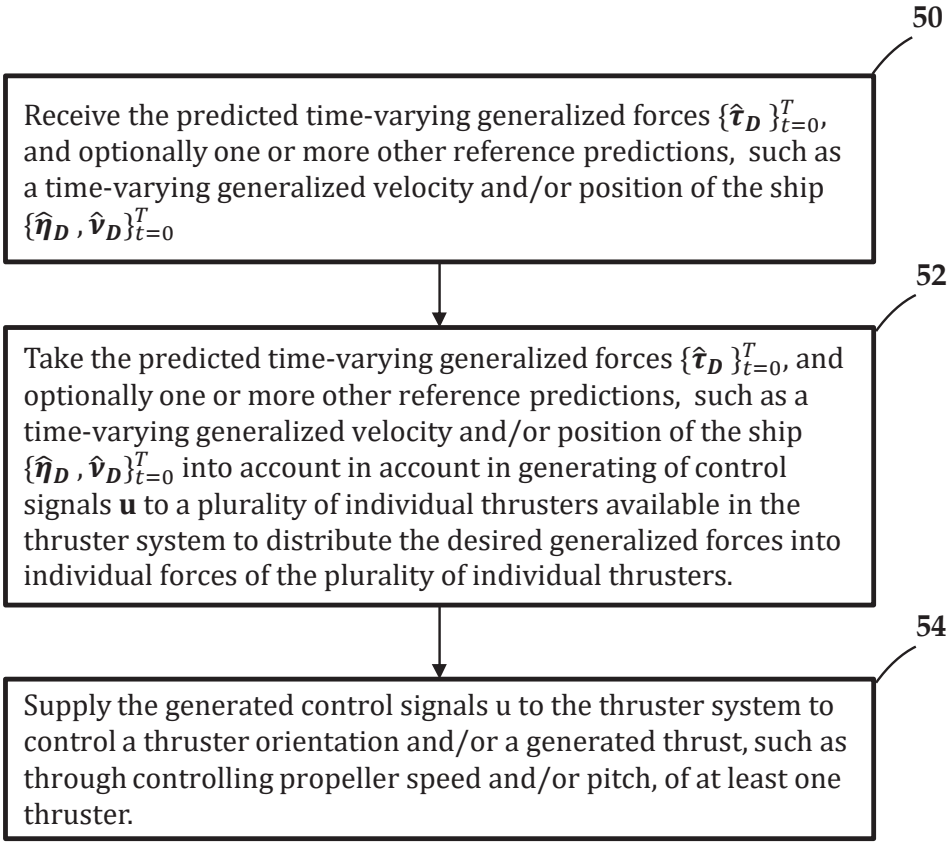

50
Receive the predicted time-varying generalized forces $\{\hat{\boldsymbol{\tau}}_{\boldsymbol{D}}\}_{t=0}^{T}$, and optionally one or more other reference predictions, such as a time-varying generalized velocity and/or position of the ship $\{\hat{\boldsymbol{\eta}}_{\boldsymbol{D}}, \hat{\boldsymbol{\nu}}_{\boldsymbol{D}}\}_{t=0}^{T}$
52
Take the predicted time-varying generalized forces $\{\hat{\boldsymbol{\tau}}_{\boldsymbol{D}}\}_{t=0}^{T}$, and optionally one or more other reference predictions, such as a time-varying generalized velocity and/or position of the ship $\{\hat{\boldsymbol{\eta}}_{\boldsymbol{D}}, \hat{\boldsymbol{\nu}}_{\boldsymbol{D}}\}_{t=0}^{T}$ into account in account in generating of control signals **u** to a plurality of individual thrusters available in the thruster system to distribute the desired generalized forces into individual forces of the plurality of individual thrusters.
54
Supply the generated control signals u to the thruster system to control a thruster orientation and/or a generated thrust, such as through controlling propeller speed and/or pitch, of at least one thruster.

Fig. 5